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ABSTRACT

Data from a brief survey of current and potential uses of minicomputers in small educational institutions suggests that the principal role of minicomputers in such institutions will be for school administration and for teaching the use of computers. In the instructional area, emphasis should be placed on teaching (1) the potentials and significance of computer applications; (2) algorithmic problem solving skills; and (3) computer programing. Recommendations for minicomputer software to support such courses are given. (DGC)

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Role of the Minicomputer in Small Educational Institutions*

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Abstract

This paper gives a brief survey of uses of and potential uses of, minicomputers in small educational institutions. We present the opinion that the principal role of minicomputers in such institutions in the near future will be (1) for school administration and (2) for teaching the use of computers. The paper suggests overall goals of courses teaching the use of computers. Recommendations for minicomputer software to support such courses are given.

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Role of the Minicomputer in Small Educational Institutions

1. Introduction

We begin by giving a working definition of the term "minicomputer", and then we discuss the general strengths and weaknesses of minicomputers. The purpose of this discussion is to lay the groundwork for Section 2 in which we give our opinions of the obvious and best uses of minicomputers in small educational institutions. Incidentally, we consider community colleges and secondary schools to be the most common examples of "small educational institutions".

What is a minicomputer? Unfortunately, the term minicomputer is used by many people with many different meanings. For the purpose of this paper, we shall characterize a minicomputer by the following two criteria.

(1) Physical size. Typically, the main components of a minicomputer (its CPU and main memory) are closer to the size of an electric typewriter than, say, a washing machine. (Not counting the power supply and racket, the CPU and memory may fit on a single printed circuit board!)

(2) Cost. Typically, the main components of a minicomputer (its CPU and main memory) can be purchased for less than $10,000 - in some cases for less than $1,000.

We have said nothing about the computing power of a minicomputer. It is not uncommon for present day minicomputers to outperform full scale computers of a few years past.

One of the principal implications of minicomputers for schools is simply this: cheaper computing.

There is a second implication which has important organizational implications. In particular, minicomputers allow distributed computing. We give some examples:

(1) A minicomputer at a community college can remove much of the need of connecting to a large computer at, say, a major university.

(2) A minicomputer could be devoted to use in teaching programming. This allows better adaptation for teaching needs as well as eliminating undesired conflicts with administration deadlines and needs for security.

Decentralization of computing can result in technical simplifications (simpler hardware and software) and therefore lower costs. Interestingly, the political and organizational benefits of decentralization can be even more important than the economic benefits. To illustrate this point, we observe that decentralization moves the responsibility for computer systems operations closer to the users; this in turn tends to make the computer system management more responsive to users' needs.

To summarize, two of the major advantages of minicomputers are (1) cheaper computing and (2) distributed computing. Bearing this in mind, we should expect no miracles from minicomputers. Basically they provide little more than did computers of a few years past. What they do provide is further opportunity for us to use computers. Hence we are faced with the questions: "What is the computer able to do that we want done?"

The answer to this question is the intersection of the answers to the following two questions (1) "What are computers good at?" and (2) "What are small educational institutions doing (or should they be doing)?" Let us consider the first of these questions.

What is a computer good at? Simplistically speaking, computers excel at two things: (1) arithmetic and

(2) record handling.

We make this point in order to concentrate attention upon the question:

(1) "How can we use minicomputers effectively?" rather than upon the question:

(2) "What are the possible uses of minicomputers?"

The second question has the honest, but unhelpful answer. "We can use minicomputers for almost anything." By contrast, the first question helps show us the practical role of minicomputers in small educational institutes.

Now consider the negative version of our question. What is a computer not good at? In these early days of the Computer Age, we sometimes delude ourselves about the ability of computers to handle certain problems. We sometimes think that a computer can handle almost any intellectual task, "all we have to do is program the computer to do the job". This attitude encourages us to waste money trying to have computers do jobs which they do not do well. What kinds of jobs are these? We give two general categories:

(1) Complex decision making. Computers can give valuable information to be used in complex situations, but remain inferior to the trained professionals in complex decision making. Perhaps the most graphic example of this is the fact that after years of research, chess play by computers remains substantially inferior to professional human play.

(2) Problem definition or asking the right question. Given a well defined problem and reasonably complete information, the computer may produce a good problem solution. However, in the everyday life of business, government and industry, problems have a habit of being ill defined and incompletely understood. The ability of people to discover the nature of a problem (e.g., by asking the right question) remains vastly superior to the corresponding ability of computers.

We have briefly probed these weaknesses of computers to help guide us to realistic use of computers-minicomputers. Most certainly, research should be done in exploring uses of computers in very complex situations; however, we should not confuse research into future uses of computers with practical uses of minicomputers in schools.

As a rule, we should concentrate on straightforward uses of minicomputers in schools, drawing heavily upon past experience with larger computers.

2. Practical Minicomputer Applications in Small Educational Institutions

We shall categorize the applications of minicomputers at small educational institutions into the following areas: (1) school administration, (2) teaching use of computers and (3) other uses. This categorization purposely emphasizes the first two categories at the expense of the third extremely broad category. That is, we are emphasizing those uses which are obviously practical and realistic and which are of interest to most schools.

2.1 School Administration We will not explore administrative uses in detail.

We can observe that cheaper computing and decentralized computing are of considerable interest to persons responsible for sending out grades, scheduling class rooms, writing paycheques, handling entrance applications and so on. At present, only some of the minicomputers have available convenient languages, such as RPG, Cobol and PL/I, for these data processing tasks.

2.2 Teaching the Use of Computers One of the primary obstacles to teaching about computing in small educational institutions has been the lack of appropriate, inexpensive computer equipment. Minicomputers will allow many schools to overcome this obstacle. Traditionally, the teaching of computer uses has come under the general areas of Computer Science and Business Data Processing. We should add to these areas any other disciplines, such as Chemistry or Library Science, which make broad use of the computer in solving practical problems. In Section 3, we discuss teaching the use of computers in some detail.

2.3 Other Uses of Computers We now give examples other less central (but still interesting) uses of minicomputers in schools.

(a) Terminals (connecting to other computers). A minicomputer can be used to connect local equipment, such as readers, printers and consoles to a remote computer. The connection may, in fact, be to a communication net, allowing access to several different computers. The advantages of such access may include: (1) use of files not locally available, (2) use of large memory, (3) use of cheap bulk computing power.

(b) Computer Assisted Instruction As practical and mature CAI packages are produced, we may see more use of minicomputers in this area. We should not expect miracles, remembering that effective computer aided instruction packages are difficult to prepare.

(c) Interactive Computing for Science and Engineering Courses. The numeric calculations performed in (for example) chemistry courses can be facilitated by use of the computer. However, the luxury of interactive computing is probably not warranted for the following types of calculations:

(1) simple calculations requiring fast response (the new, cheap, hand-held electronic calculators are probably superior for these calculations) and

(2) extensive calculations (batch processing is inherently cheaper for such applications, and it is often the case that the short response time implied by time sharing is not required)

(d) Rapid Data Collection: Some experiments can generate great quantities of information in a short time. For example, a researcher may wish to take 20,000 observations a second of

the air flow in a wind tunnel. Because of their flexibility and relative cheapness, minicomputers can be used as (a part of) special purpose equipment in such experiments. At the present time, it appears that most of this type of work belongs to the field of research rather than that of education.

(e) Automatically Controlled Experiments Minicomputers are being used to control experiments, as well as to record observations. For example, an animal psychology experiment might call for the rewarding of a rat after the rat performs some particular task. A minicomputer can reliably administer such experiments.

(f) Teaching about Process Control There are a number of important applications of minicomputers in which the computer observes and controls industrial processes. For example, in a cement factory, a minicomputer can control additives and kiln temperature. As the use of minicomputers in such industrial applications increases, we may see a need to use minicomputers to teach about these applications.

(g) Computer Hardware Studies Students of electronics need electronic gear for their training. When studying computer hardware, one certainly needs example equipment, such as a CPUs. When a minicomputer is used for such purposes, it seems more appropriate to regard it as a piece of training equipment, comparable to an oscilloscope, rather than as a computing machine. There should probably not be an attempt to use this same equipment for other purposes, such as for teaching programming.

We now return to the problem of using minicomputers in teaching the use of computers.

3. Teaching about Using Computers

Our goals in teaching about using computers should not derive primarily from the equipment at hand. Rather, we should focus upon actual, realistic uses of computers. This means that, whether we have available a large computer or a minicomputer, the material we present should be similar. We now give our ideas about this material.

Going from the general to the specific, the material we should teach about using computers includes (1) applications of computers, (2) algorithmic problem solving, and (3) programming.

Applications of Computers. Students should learn of uses of computers such as: data processing, data base management, similations, numerical solution of mathematic problems, text editting, airline reservations systems, process control, etc. Not only should the student learn something about these uses of the computer, he should also learn the significance of these computer uses. He should be introduced to social issues of computing such as privacy of personnel files, security of business files, possibilities of computer surveillance, job displacements caused by computers, the possibility of a cashless society, and so on.

Algorithmic problem solving. The student should learn about step-by-step problem solutions. He should learn about precise specifications and communication, such as is necessary in a programming language. He should learn about structured problem solution; these methods successively break a problem into sub-problems, and sub-problems into sub-sub-problem, etc., until the constitutuent parts of the problem are sufficiently small to allow immediate solution. In many cases, the final level of factoring

can be expressed directly in terms of a programming language. That is, the final level of factoring can produce a computer program which solves the original problem.

Programming. Computer programming is an interesting and marketable skill. It is natural to teach each of the above (applications of computers and algorithmic problem solving) using the computer as a vehicle; in particular, by having students solve simple application problems by writing programs.

Traditionally, teaching about using the computer proceeds from the specific (programming) to the general (computer applications). Only a fraction of the students studying programming will make much direct use of the skill. However, the problem solving techniques used in programming are useful in many fields of endeavor.

4. Minicomputer Software for Teaching

In order to be an effective teaching tool, a minicomputer system must satisfy the following criteria:

Reliable. It must consistently do the requested computation.

Tolerant of User Errors. It must not be too exacting for the novice user. It should provide reasonable diagnosis of incorrect student programs.

Consistently good turnaround (or response). The student and teacher should know that computations will be done soon (say, at worst, within 24 hours), and the time required to complete the calculation should be predictable.

Cheap. Running of a student job should not require more than a few seconds of use of the computer equipment. Otherwise, student use of the computer may be too expensive to allow sufficient student exposure.

Unobtrusive and inconspicuous. Ideally, use of the computer should be a simple matter, requiring little memorization of details about equipment, program entry, etc. This does not imply that programming itself is easy (it is not), but rather that the mechanics of using the equipment should be easy.

Good Programming Language. The programming language available to the student is of great importance. We will present some definite views about computer languages later in this section.

The author of this paper is presently involved in research supported by the Ontario Ministry of Education; this research has lead to specific (but still tentative) recommendations for minicomputer software to support Computer Studies in Secondary Schools. We now briefly list some of the

conclusions of that research.

Use of a "real" computer language. Inventing a new computer language is a difficult and risky business; we prefer use of an existing, widely-used language. The obvious candidates include Fortran, Algol, PL/I and Basic.

Use of Batch Processing. We favour batch processing (over interacting computing) due to its economy and technical simplicity.

Use of a "Structured Language". We recognize that structured solutions to problems are easier to produce given certain computer language features. In particular, it is helpful if the language contains loop and conditional constructs which do not require the GOTO statement. Algol and PL/I offer such constructs.

Use of Mark Sense Cards. Scheduling the use of keypunches (and paying for keypunches) is a problem in many schools. To overcome this problem, we recommend that the minicomputer be able to accept programs and data on mark sense cards. (Note: care must be taken in designing convenient, special purpose mark sense cards.)

We are concerned about the difficulty of implementing appropriate minicomputer software, and so we wanted a language which could be easily compiled.

Having had considerable experience with Fortran, we hoped to overcome the following weaknesses:

(1) difficulty in handling characters,

(2) clumsy handling of simple input/output,

(3) tedious and seemingly arbitrary restrictions upon various constructs, such as subscripts.

We found that the PL/I language provided most of the features which were needed. However, PL/I is a huge language and brings with it (a) many non-essential and unwelcome features and (b) a reputation for being extremely difficulty to compile. To overcome these problems, we carefully subsetted the PL/I language, leaving in only those features which meet the above recommendations. The result is a sequence of successively larger "structured" subsets of PL/I; the sequence is called SP/k.

We are now in the process of demonstrating that SP/k is a useful language for use on a minicomputer. Initially, we are working with a DEC PDP-11 minicomputer. This work is still underway. We have previously implemented an SP/k compiler for the IBM System/360/370 and have been using this compiler in teaching courses at the University of Toronto and in Toronto high schools.

5. Conclusions

We will now summarize the main points of this paper. We stated that minicomputers allow (1) cheaper computing and (2) distributed computing. As such, we should not expect miracles from minicomputers, but rather should expect them to allow increased use of computing and local control of computing facilities.

For the near future, we can expect to see use of minicomputers in small educational institutions primarily (1) in school administration and (2) teaching of the uses of computers. In this latter regard, we should be teaching (1) the potentials and significance of computer applications, (2) algorithmic problem solving and (3) programming.